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THE NINTH ANNUAL INSECT POPULATION SUMMARY OF KANSAS—1939[1]

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This ninth annual summary utilized she same sources of information as were used in preparing the previous summary except that the questionnaires were not sent to the county agents in October because they had been called upon too frequently for information of various kinds during preceding months. The method of summarizing the data and preparing this report for publication differs in no respect from the prevous one[4].

Table I records the totals of questionnaire reports which were used in preparing Table II of this summary.

TABLE I

Questionnaires returned and summarized for the report.

	No. in July	No. in October
Group 1. Entomologists in the state	17	14
Group 2. County Agr. Agents	94	1
Group 3. Farmers, mostly college graduates	16	7
Group 4. Vocational Agr. Teachers	30	74
Total reports	157	96
Grand total of all questionnaires summarized for this report		253

*Contribution No. 493 of the Department of Entomology.

[1]This report includes results obtained in work on Project No. 6 of the Agricultural Experiment Station. Recognition for assistance in supplying information is due the same sources given in previous summaries.

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[4]References to the previous summaries are as follows:

1931: Jour. Kans. Ent. Soc. 5(3): 65-92. 1 pl. 1932.
1932: do. 6(2): 37-60 1 Pl. 1933.
1933: do. 7(2): 37-51. 1934.
1934: Trans. Kans. Acad. Sci. 38:171-85. 1935.
1935: do. 39:129-149. 1936.
1936: Jour. Kans. Ent. Soc. 10(4): 113-32. 1937.
1937: do. 11(2):54-176. 1938.
1938: Trans. Kans. Acad. Sci. 42:303-323. 1939.

SUMMARY OF WEATHER CONDITIONS IN KANSAS DURING 1939[5]

January had exceptionally mild weather in temperature and a good supply of moisture fell in the southern half of the state including 4 to 9 inches of snow in the eastern part of the area. There was a pronounced deficiency of moisture over the northwest quarter of the state.

February was a month of heavy snows over the state and good rains in southeast Kansas. It was a cold month but was more sunshiny than usual. Ten to 15 inches of snow fell over the northern two-thirds of the state and 4 to 10 inches in the southern third. Soil moisture was seriously deficient.

March had generous and well distributed moisture falls with mild temperatures after the first few days. Snow and rain were most plentiful in the western third of the state. It was the wettest March in 8 years while the temperature and sunshine were near normal.

April was deficient in rain fall and the temperatures for the first three weeks were abnormally low. Severe freezes early in April caused a cold late spring. Warm, drying winds the last week were unfavorable to crops.

May was the third warmest on record being 4.6° above normal, and in most sections one of the driest. More rain than needed fell in southeast Kansas. Wheat deteriorated in many parts of western Kansas especially in southwestern counties.

June was the wettest in 4 years. The temperatures were slightly above normal but withal it was a comfortable month of good growing weather. Wheat harvest in many southern counties was hindered by rains and muddy fields.

July was the fifth warmest and seventh driest experienced in the state since 1887. Excessively high temperatures, the almost complete lack of rain, the bright sunshine and drying winds made this a most uncomfortable and unfavorable month. Practically all crops deteriorated.

August was another hot, exceedingly dry month though considerably more rain fell than in July. The rains came largely in local showers which the hot, dry winds soon dissipated. Crops in the eastern two-thirds of the state improved some early in the month but they deteriorated generally near the close.

September broke all records in the history of the state for a combination of heat, drouth and unfavorable crop growing weather. There was almost no rain and dust storms occurred frequently in southwestern Kansas. Pastures declined, sorghums failed to fill properly in many places and wheat sowing over the western half of the state was largely delayed.

[5]Summarized from Flora, S. D. Climatological Data, Kansas Section. U. S. Dept. Agr. Weather Bur. 53. 1939.

TABLE II

Summary of weather data for Kansas for the insect year Sept. 1938 to Dec. 31, 1939.

	Temperatures: degrees Fahrenheit					Precipitation, in inches					
Month	State Average	Maximum	Minimum	Average for 52 years.	Departure from normal	State average	Average for 52 years	Departure from normal	Eastern third	Middle third	Western third
September 1938	72.3	103	31	69.7	+2.6	2.19	2.82	-0.63	2.24	1.88	2.45
October	64.8	100	11	57.1	+7.7	0.33	1.92	-1.58	0.49	0.15	0.35
November	42.6	83	-2	43.2	-0.6	1.40	1.28	+0.12	2.45	1.57	0.17
December	36.2	78	-10	33.0	+3.2	0.20	0.84	-0.64	0.31	0.11	0.17
January 1939	38.3	76	-1	29.9	+8.4	0.78	0.67	+0.11	0.99	0.73	0.63
February	30.4	70	-18	33.0	-2.6	1.22	1.00	+0.22	1.38	1.25	1.03
March	45.5	88	-6	43.4	+2.1	1.72	1.44	+0.28	1.99	1.53	1.63
April	54.5	98	13	54.7	-0.2	1.96	2.52	-0.56	3.17	1.59	1.13
May	68.5	108	32	63.9	+4.6	2.35	3.83	-1.48	3.45	1.95	1.66
June	75.3	110	40	73.8	+1.5	4.59	3.99	+0.60	5.64	5.52	2.60
July	83.4	116	55	79.1	+4.3	1.40	3.16	-1.76	1.31	1.49	1.39
August	78.1	112	45	77.9	+0.2	3.50	3.10	+0.40	4.59	4.57	1.35
September	75.5	113	24	69.8	+5.7	0.32	2.77	-2.45	0.50	0.27	0.19
October	61.1	101	18	57.2	+3.9	0.60	1.90	-1.30	1.05	0.64	0.10
November	44.3	80	4	43.2	+1.1	0.83	1.27	-0.44	1.68	0.66	0.14
December	39.0	86	-13	33.1	+5.9	0.81	0.84	-0.03	0.79	0.71	0.94
Average or totals for 1939		113	-13	54.9	2.90	20.08	26.49	-6.41	26.54	20.91	12.80

October was the fourth driest October known in Kansas which, with September, was the driest two months period ever recorded in the state. The drouth in the western third was particularly severe, there being only about one-third normal precipitation. Temperatures were well above normal though freezing weather arrived in the last four days. Some wheat was drilled in dust in western counties.

November was mild and sunshiny but unusually dry. Conditions were unfavorable to wheat especially in the western half of the state. Rainfall was below normal in almost every county. This month ended the driest three months ever recorded for this time of year, there being less than 30 percent normal precipitation. Temperatures were slightly above normal and remarkably uniform.

December had three weeks of unusually mild weather but during the last ten days, colder weather with snow and near zero temperatures prevailed. Rains on the twenty-third and twenty-fourth relieved the fall drouth somewhat. Wheat was in poor condition over most of the state.

The year as a whole was the third mildest and fifth driest in 53 years. Soil moisture was markedly deficient except for May and June. Rains during these months contributed to a cool late spring.

"Total 1939 production of major crops in Kansas was quite low compared with 1938 and with the average"[8] being 23 percent below 1938 and only 71 percent of the 1927-36 average. This was a result of the lower crop acreage harvested and generally lower yields per acre. The 1939 wheat crop of 111,657,000 bushels compares with 152,184,000 for 1938 while 37,330,000 bushels of corn in 1939 compares with 45,200,000 for 1938 the crop being almost wholly in the eastern part of the state. Alfalfa and other hay totaled 994,000 tons in 1939 against 1,171,000 tons in 1938. Potatoes yielded 2,128,000 bushels in 1939 against 3,219,000 in 1938. The barley crop of 7,480,000 bushels in 1939 was larger than the crop of 6,681,000 bushels of 1938 but there were nearly twice as many acres harvested in 1939—680,000 acres against 395,000. Likewise the flax, apple, peach and alfalfa seed crops in Kansas exceeded the 1938 production somewhat. The total value of all crops was estimated at $133,606,000 in 1939 against $145,241,000 in 1938.

[8]Logan, K. E. and Gilbert, Samuel J. Kansas 1939 Crop Review. Kans. State Bd. of Agr. Div. of Statistics, Dec. 21, 1939. (Mimeographed).

TABLE III. Population summary from the 253 questionnaires returned in July and October from all the counties in the state except Ellsworth, Hodgman, Morton, Russell and Sherman. Key: 0-The species is practically absent; 1-scarce; 2-common but not injurious; 3-plentiful and some damage was done; 4-abundant, serious injury to some fields in many communities; 5-outbreak or as plentiful as a common species has been in years of larger populations.

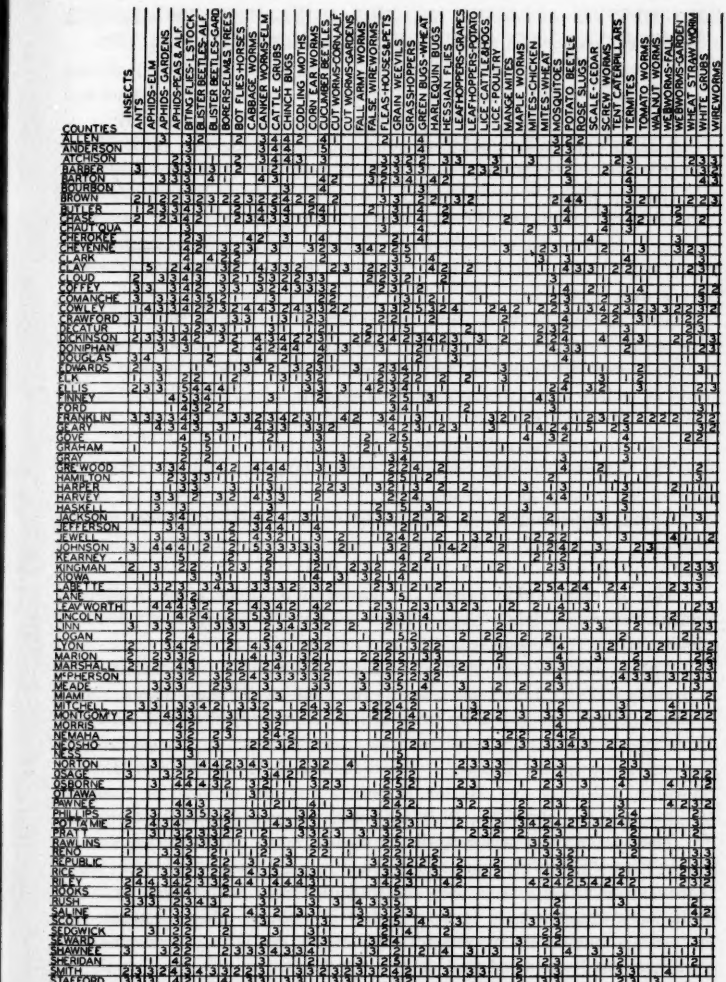
INSECTS
COUNTIES
ANTS
APHIDS-ELM
APHIDS-GARDENS
APHIDS-PEAS & ALF.
BITING FLIES-L. STOCK
BLISTER BEETLES-GARD.
BLISTER BEETLES-ALF.
BORERS-ELMS & TREES
BOT FLIES-HORSES
CANKER WORMS-ORCH.
CANKER WORMS-ELM
CATTLE GRUBS
CHINCH BUGS
CODLING MOTHS
CORN EAR WORMS
CUCUMBER BEETLES
CUT WORMS-GARDEN
CUT WORMS-ALFALFA
FALL ARMY WORMS
FALSE WIREWORMS
FLEAS-HOUSES & PETS
GRAIN WEEVILS
GRASSHOPPERS
GREEN BUGS-WHEAT
HARLEQUIN BUGS
JUNE BEETLES
LEAFHOPPERS-GRAPES
LEAFHOPPERS-POTATO
LICE-CATTLE & HOGS
LICE-POULTRY
MANGE MITES
MAPLE WORMS
MITES-CHICKEN
MITES-POULTRY
MOSQUITOES
POTATO BEETLE
ROSE SLUGS
SCALE-CEDAR
SCREW WORMS
TENT CATERPILLARS
TERMITES
TOMATO WORMS
WALNUT WORMS
WEBWORMS-FALL
WEBWORMS-GARDEN
WHEAT STRAW WORM
WHITE GRUBS
WIREWORMS

TABLE III

DESCRIPTIVE ACCOUNT OF THE MORE STRIKING INSECT ACTIVITIES AND CLIMATIC RELATIONSHIPS FOR 1939.

Ailanthus web warms were more plentiful than usual during August and September in 1939. Practically every ailanthus tree had one or more webs in it with noticeable to severe foliage injury.

Alfalfa caterpillars attained normal numbers during 1939. Slight injury was done by this species to some irrigated alfalfa at Halstead and Garden City.

Anomea laticlavia Forst. a chrysomelid beetle was reported causing injury to fruit tree foliage in Labette and Chautauqua counties during June. It had been reported from Leavenworth County during July 1938.

Ants in houses were less numerous in the state than in 1938. They were reported chiefly from the eastern three tiers of counties and the two tiers south of Phillips and Smith Counties.

The **yellow ant** swarmed into basements of Riley County during March and April in usual numbers. Specimens were seen in March from Brown and Gray Counties.

The **Kafir ant** was reported from Jackson County attacking planted kafir seed in early June.

Aphids appeared in several fairly well defined outbreaks during 1939 and in general were probably slightly more abundant than in 1938.

The **boxelder aphid** curled the leaves of boxelder trees in eastern Kansas severely during May. There was much honey dew produced which attracted flies noticeably.

Aphids on cabbage, radish, turnips, cucumbers and melons were extremely plentiful and destructive in eastern Kansas during May. Plants not dusted repeatedly were killed or severely dwarfed by them. They were observed abundant and destructive on cucumbers in Norton, Washington, Marshall, Smith, Haskell, Ellis, Phillips, Rooks, Sheridan, Mitchell and Butler Counties and on melons in Stanton, Dickinson, Edwards, Ellis, Phillips, Smith, Kiowa and Riley Counties.

The cottonwood petiole gall aphid was more numerous in Kansas during June and July than for some years. Specimens were seen from Jewell County and also many galls from Riley County. The galls were exceptionally large and full of aphids. Some appeared to have been opened by wood peckers. Many leaves appeared to have been artificially severed and fell to the ground.

Elm leaf aphids (Myzocallis ulmifoliae) occurred in an unusually late outbreak throughout the state wherever there were elm trees during August to October. The blackish areas of honey dew under elms on pavement, sidewalks and the spots on cars were common over most of the state during the autumn. Honey dew continued to drop from the shiny leaves after the aphids were gone or up to about

September 20 when the leaves dropped.

The green bug (**Toxoptera graminum**) occurred in one of the severest outbreaks since 1916. Dr. R. H. Painter summarized the outbreak as follows:

"In 1939 green bugs spread from Oklahoma and Southern Kansas, where they overwintered in barley and volunteer small grain, across the state doing damage late in the season to fields of wheat thru the central third of Kansas. Hymenopterous parasites were not seen nor reared from green bug infested wheat around Manhattan, but lady beetles were abundant. The aphid was first reported plentiful on April 14 on barley in southern Kansas. Feeding of the green bugs during May and June was principally inside the upper leaf sheath about the developing head of wheat. In many spots in fields and occassionally whole fields of wheat, the plants were one-half to one-third normal height, the heads poorly exserted, fusiform in shape and often with less than one-half the normal amount of grain which was partly shriveled. In a few spots, plants were killed before they were half grown. Damage was widespread in the central and western parts of the state but was complicated by the presence in some areas by drouth, dry land foot rots, brown mites and red spiders. Plants showing about medium injury from river bottom fields near Wakefield where green bugs were the primary agent of injury showed an average loss of 2.3 pounds per bushel test weight and 50 percent in yield."

Injury to barley, wheat or oats was observed in Sumner, Sedgwick, Harvey, Butler, Reno, Rice, Edwards, Montgomery, Chautauqua, Cowley, Smith, Ellsworth, Barton, McPherson, Marion, Dickinson, Geary and Riley Counties. Spots of apparently damaged wheat were readily observed up to June from the highways in the counties mentioned. It is regarded as somewhat unusual for these aphids to be on the wheat heads since they are ordinarily gone by the time of heading.

The **pea aphid** occurred in almost destructive numbers in the eastern half of the state and in the Arkansas River Valley in the west. Severe injury to some fields was reported from Finney, Montgomery, Wyandotte, Marion, Harvey, McPherson, Atchison, Jefferson, Douglas and Johnson Counties only. Large populations with less injury occurred in Commanche, Barber, Chautauqua, Cowley, Sumner, Riley, Dickinson, Geary, Reno, Rice, Elk, and Butler Counties. Pea aphids were first seen about April 10 but they were scarce. April 15, Prof. D. A. Wilbur observed severe damage to small areas in some fields of alfalfa near Garden City. Lady beetle and Chrysopid larvae and adults were numerous everywhere but the weather was too dry before June for the fungus disease. Typically damaged small areas of alfalfa in fields were seen the middle of May in the

general area around McPherson County presumably caused by pea aphids. Ample rains beginning May 20 and extending through June enabled the plants to recover. There was loss in hay of the first cutting but the loss of stands was small. These aphids continued plentiful during the first half of June when natural enemies and fungus reduced them to usual numbers.

Some farmers used a sheet of galvanized corrugated roofing as a drag to catch the aphids. One farmer reported catching 13 tubs full in this way from 10 acres of alfalfa.

The **apple leaf skeletonizer (Psorosina hammondi** (Riley) defoliated apple trees in Northeastern Kansas during early July. They appeared first, according to Dr. R. L. Parker, in the tops of poorly sprayed apple trees and most of the leaf loss occurred in the tree tops. It has been many years since an outbreak occurred but the species appeared to be increasing.

Blister beetles declined somewhat in numbers from 1938 but were still plentiful over the entire state. They were most numerous in central and western Kansas in alfalfa fields and gardens, the latter being ruined in many counties during July and August. Many beets, carrots and even Chinese elms in Gove, Meade, Finney and Rush Counties were largely defoliated. Some beetles emerged as early as May 31. They occurred in great numbers in small scattered spots of alfalfa near Garden City in July and destroyed areas of blossoms. Blister beetles were serious pests of sugar beets in Finney, Kearney, Scott and other counties.

Borers in elms and other shade trees were again numerous but the scorings show them to have been less destructive than in 1938. They were particularly severe in the northwestern part of the state which was the driest. The good rains in June resulted apparently in the destruction of many borer larvae and enabled the trees to recover somewhat from previous injuries. Borers were reported injuring elm, oak, ash, cottonwood, hackberry, locust, popular, maple, red cedar and boxelder trees.

Common stalk borers (Papaipema nebris Gue.) were more numerous in Riley County during 1939 than in 1938. The larvae were collectent during June in grasses, corn, sweet clover and castor bean.

The **corn seed beetle (Agonoderus pallipes** Fabr.) was more plentiful at lights and in flights particularly in Riley, Finney and Coffey Counties than in 1938 but in both years they were below normal numbers. The only damage reported was to germinating milo seed during July at Hugoton.

Bot flies were probably less numerous and destructive than in 1938, probably because county agents reported that 19,385 horses were treated in Kansas in 1939 against 17,121 in 1938. This is particlarly true in the western half of the state where horses are used

chiefly for herding cattle. Bots have been worst in southeastern counties.

Boxelder bugs were active during the warmer days of March and had scattered from their hibernating quarters by April 3. They were more annoying in previous years but the population in general is still well below that of peak years.

These bugs were practically absent during the summer but they collected in about the same numbers as were present in the spring at their favorite hibernating places for over-wintering.

Cactus borers (Melitara dentata Grote.) did more injury to cactus plants all over the state than for many years. Practically every cactus plant was attacked during the summer, the majority of them being severely riddled. The bluish caterpillar of the above species was by far the most plentiful species involved. These caterpillars spun silken cocoons either in the hollowed leaves or in the roots when grown. A Cerambycid larva, probably **Monolema annulatum** Say, was observed by Mr. Roy Fritz in Scott and Logan Counties to have been more numerous than ever before and many cactus clumps were destroyed by them. The larva bored into the main root or crown of plants. Two uncommon Syrphid flies (**Copestylum marginatum** and **Volucella** sp.) were reared from western Kansas plants in large numbers. The larvae lived in the empty burrows made by other insects.

Canker worms occurred in the biggest outbreak for many years in the eastern half of Kansas during the spring of 1939 and caused extensive defoliation of elms, hackberry, boxelder, and apple trees as far west as Ellsworth. Both the fall and spring cankerworms were delayed by the drouth in their emergence in Riley County, according to Dr. R. L. Parker. The peak of the emergence of the fall species occurred on March 8 and of the spring cankerworm on April 1st. Defoliation was particularly severe in the Neosho and Verdigris river valleys.

The outbreak was particularly severe around Kansas City and in McPherson and Saline Counties but not in Manhattan and Clay Center. Their absence in these two towns demonstrated the value of banding and spraying during previous years. Elms along creek banks and in small wooded areas were in many cases completely defoliated. Such conditions were observed in Riley, Reno, Rice, Saline, Dickinson, Clay, Pottawatomie, Shawnee, Jefferson, Leavenworth, Atchison, Wyandotte, Lyon, Osage, Jackson, Johnson and Douglas Counties. Apple trees were severely attacked in Doniphan, Atchison, Brown, Johnson, Franklin, Cowley, Sumner and Pottawatomie Counties. Chinese elms were attacked for the first time so far as known, in Atchison County. Only poorly cared for orchards had severe defoliation and the values of banding and spraying were never more in evidence.

Their Carabid enemy, **Calosoma scrutator** was particularly plentiful also.

The larvae were nearly full grown in Riley and surrounding counties by May 15. The rains of early June enabled the trees to put out a good crop of leaves during the month.

The **carrot beetle (Ligyrus gibbosus)** was abundant in Riley at lights during May and again caused injury in the western part of the state during August and September. Tomatoes and celery were killed in some gardens.

Cattle grubs were more numerous in the state during 1939 than for many years. The county agents reported that 1635 farmers applied control measures to 23,603 cattle in 1939 against 1492 farmers and 11,956 cattle in 1938. Many cattlemen had difficulty marketing grubby cattle in the spring.

Cattle grubs were most numerous in the Flint Hills pasture section of eastern Kansas. The flies were first observed causing cattle to run on March 26 in Wabaunsee and Riley Counties, on April 9 in Dickinson County.

Starlings attacked cattle during the time snow covered the ground December 26, 1939, to about February 15, 1940. Food was scarce for them as was true for many birds. Larger flocks of starlings were common around herds of cattle in stalk fields and feeding lots than were ever seen before. The birds alighted on the backs of cattle, in some cases to feed upon cattle grubs but in other cases to peck at scratches, wounds, recent brands, and warble tumors. Many animals had areas the size of a hand where the skin had been removed by the starlings. Wounds could not heal because of their persistent attacks. Cattle were injured in their efforts to escape the attacks of the birds which followed them closely. Meadow larks also occurred with the starlings and were reported probably incorrectly doing similar injury. Many reports were received chiefly from the southern part of the state and in particular Chase, Rice, Morris, Harvey, Meade, Russell and Riley Counties.

The **common cabbage worm,** though more numerous than in 1938, was somewhat less destructive than in previous years. Injury was reported only in eastern Kansas, in the Arkansas River valley and the northern tier of counties in the west. Rain during June favored the growth of cabbage.

Codling moths were apparently more numerous in the apple district of northeastern Kansas in 1939 than in 1938. The catches at bait traps reported by P. G. Lamerson at Troy and Wathena were consistently two to seven times greater in 1939 from early May to September 30 than in 1938. Only during June were fewer moths taken.

The **Colorado potato beetle** was more plentiful and destructive

than usual during June. The first generation was exceptionally large.

Corn bill bugs were considerably less plentiful and destructive in 1939 than in 1938. They occurred chiefly in the eastern half of the state especially in the southern quarter. It is believed that rotation of crops on bottom lands has reduced their numbers.

Chinch bugs, after a relatively unimportant first generation, built up to the largest numbers in 10 years in the second generation and went into hibernation in the fall. During April, 10-15 bugs occurred to a clump of native grasses over most all of the eastern half of the state. They were scarce in southeastern Kansas but more plentiful north of the Kaw. The relatively few survivors from the severe winter scattered late to thin spots in wheat and barley fields. Egg laying was delayed by the cold spring to late May. The first generation was of sufficient size in many eastern counties especially north of the Kaw river to cause farmers to purchase barrier material. They were most threatening in Brown, Nemaha and Marshall counties. However, there were few migrations from wheat fields by crawling. The bugs matured in grain fields especially on **"fox tail"** and flew to sorghum and corn fields. Widespread and occasionally serious injury was done to many sorghum fields by these adult bugs. Young milo and replanted sorghum plants were severely attacked and some were seriously affected especially in 12 northeastern counties. Sorghum plots at the college farm were saved only by heroic control efforts but the stands were reduced and growth delayed. Barriers did not yield the protection usually expected because the bugs scattered by flight instead of on foot.

The second generation was a large one and caused heavy loss to corn and sorghum. Fall weather was favorable and maturing bugs were seen in greater numbers than for many years seeking winter quarters from the last of August to early October. Adult chinch bugs were everywhere. They were taken frequently in homes. For the first time in many years, adult chinch bugs damaged sorghums particularly in southeastern Kansas during the fall.

The chinch bug situation appeared so threatening in the fall of 1939 that the U. S. Bureau of Entomology and Plant Quarantine made a fall survey. In short, the largest population in years was discovered in hibernation in 50 counties east of highway 81. The western limits of the larger number extended to Jewell, Cloud, Sedgwick and Sumner Counties. As many as 3000 bugs to the square foot were found as far west as Washington and Clay Counties.

Crambid moths were distinctly less plentiful at lights and in grass during 1939 than in 1938. Larvae were difficult to find.

Cutworms of the usual species occurring early in the state were almost completely absent in the spring of 1939 all over the state. Most species were less plentiful than for years. It is believed that

they have been reduced by parasites and hot, dry weather.

The most plentiful was the **pale western cutworm** which, according to H. H. Walkden, was again in outbreak numbers in western and northwestern Kansas and was responsible for killing some 10,000 acres of wheat. His surveys of the situation indicated that they were as plentiful as last year and in approximately the same counties. Heaviest injury to wheat and barley occurred in April and May in Rawlins and Thomas Counties, but losses were reported also from Gove and Meade Counties. Wheat on fallowed land was injured only when near stubble fields. Many patches of dead wheat in most central western Kansas fields were thought to have been results of feeding by this species. There was a heavy flight of moths of this species in Rawlins and Thomas Counties in September, according to Mr. Walkden.

Wheat head army worms were present in larger numbers than usual and some injury up to 25 percent was done to wheat in Morris County during early June. However, in the state as a whole there was little or no commercial damage done.

The **army cut worm** was the scarcest in years. Few specimens were seen.

Corn ear worms did widespread curl damage to corn in early June. This species attained normal numbers or more during the latter part of August on late sweet and field corn and in alfalfa. The moths were unusually plentiful hiding in shrubbery and grassy lawns in early September. The larvae were about as plentiful in fall growth of alfalfa as occurs in peak years. Late planted corn was practically 100 percent injured by the larvae. They also damaged sorghum heads in the fall.

The **variegated cut worm** was fairly plentiful though below normal in certain alfalfa fields in Riley County the last of May. As usual, they were most plentiful in some bottom fields where the growth was tall enough to shade the ground. They were heavily parasitized by Tachinids. No injury was seen nor reported.

Black Crickets were again annoying in homes but probably fewer reports came in than in 1938.

Common field crickets again damaged the seed crop of alfalfa in Garden City area. As much as 50 percent loss was experienced from crickets cutting off the heads and eating the seed while the curing seed stalks were in piles in the fields. The crickets were half grown and extremely numerous by early July. One could readily find as many as 15 to 20 to the square yard.

False wire worms (Eleodes opaca and **E. coloradensis)** were again plentiful and destructive to fall sown wheat in extensive areas in western Kansas. The exceptionally severe drouth during September favored the species and greatly extended the loss. False wire

worms have extended their range eastward. Heavy populations were seen in Dickinson, McPherson, Ottawa, Saline, Republic, Cloud and Clay Counties. It was estimated that over 600,000 acres of wheat had to be replanted in the fall of 1938; some were planted to barley both in the fall and spring and an estimated 200,000 acres were planted to corn and kafir in the spring of 1939.

Fleas in houses, in barn lots and on pets caused more inquiries than usual.

Biting flies (horn and stable) occurred in several outbreaks of relatively short duration and were as numerous in the state as in the more severe fly years. The stable fly caused annoyance to stock in southeastern counties as early as April 20. A widespread outbreak occurred during May and June with stock losses in southcentral counties.

Horse flies (Tabanids) were less plentiful in 1939 than in 1938. They were present in largest numbers along streams in southeastern Kansas in July. Traps in Butler and Elk Counties caught large numbers in July and August.

Screw worm flies were again in outbreak in Kansas in 1939 particularily in the eastern half of the state. Screw worms were brought into the state from southern Texas and New Mexico by shipments of some 50,000 cattle reaching Lyon and Greenwood Counties April 17. They had been dehorned before shipping and these wounds as well as those resulting from castration and scratches were badly infested. While these animals were examined and treated with benzol, complete control was not obtained. The flies then attacked young calves and other animals in Cowley, Butler, Sumner, and Chautauqua Counties. An outbreak developed in Meade County in dehorned cattle shipped from New Mexico during early June. A man was known to have been treated for screw worm flies. Some 5,000 cattle were treated with a mixture of honey, pine tar and crysillic acid with excellent results. Sheep were attacked in Cowley, Lyon, Pottawatomie, and Sumner Counties; hogs in Sumner and Butler. Screw worms continued to be a pest in the state in eastern Kansas until the middle of October.

Grasshoppers were less numerous in Kansas in 1939 than in 1938 but they were in outbreak in western and especially southwestern counties. The adult and egg survey in the fall of 1938 indicated that they would occur in some 65 western counties.

The distribution of nymphs in April and May was general, being heaviest, however, in the western half of the state. Populations up to 400 nymphs to the square foot were reported and a widespread severe outbreak appeared certain in 60 or more counties.

Excellent rains in May and June caused the fungus disease to develop practically over the entire state which was an effective

control in 12 central counties extending to and including Republic, Saline, McPherson, Reno and Pratt Counties. The early picture in the border area changed remarkably from June to August.

M. mexicanus, the migratory grasshopper, was the most numerous and wide spread species. The eggs were largely hatched by the middle of May and the nymphs were doing damage by the middle of June. The species occurred at the edges of fields, in wheat, oats and barley stubble and in wheat fields where stubble and trash were left on the fields. Flights by this species were observed and reported in early July in Wallace, Logan, Johnson, Sherman, Hamilton, Greeley, Finney, Scott, Meade, Haskell, and Seward Counties. As many as 450 grasshoppers per square foot, 94 percent of which were **mexicanus** were observed alighting near Garden City. The second generation of this species began appearing the last weeks of July but many perished for a lack of food.

Aeoloplus turnbulli bruneri, the thistle hopper, followed a similar life cycle and approached the migratory species in numbers and damage. This hopper is however a western species and was the dominant species in the northwest from Mankato west to Medicine Lodge northwestward. They were particularly injurious to sugar beets in the Garden City area. They damaged wheat by cutting off the ripening heads. This species is spreading eastward. The rapid increase of this species the last three years is an outstanding feature. It had no important parasitic enemies. It clustered on Russian thistle and lays its eggs under them. Its eggs do not dry out.

Melanoplus differentialis, the differential grasshopper, was somewhat less plentiful than normal and caused little damage in the state

M. bivittatus, the two lined hopper, was the dominant species in Central and Eastern Kansas. The first adults occurred in July. The nymphs cut off many heads in Finney and Seward Counties, according to Mr. Roy Fritz, causing severe loss.

The longwinged plains hopper was not a pest in the state in 1939, but was observed in Mitchell, Jewell, and Stafford Counties.

Climatic and other natural forces were primarily responsible for reduction of grasshoppers to harmless numbers in the eastern half of the state. Rains in June favored development of diseases which apparently destroyed many hoppers in the eastern half of the state. Thistle hoppers killed by the fungus were seen in Wallace County in July. There were not enough hoppers around Manhattan for experimental work.

Some 3,048,000 acres were tilled by 25,684 farmers in the state to destroy the eggs and young hoppers with good results.

There were used in Kansas, during the summer and fall of 1939, 84,531 sacks or 8,800,000 pounds of wet mixed bait by farmers in 1939 and 2,634,000 pounds of dry mixed bait by the federally employ-

ed men in eight southwestern counties designated as the "longipennis" area. Thirteen thousand three hundred and ninety-four farmers spread 8,800,000 pounds with the use of 640 mechanical spreaders and their own hands on 880,000 acres protected thereby 3,459,638 acres at a cost of $70,000 saving crops valued at $3,668,000. These amounts are from one-third to one-fourth of the amounts used last year indicating the smaller grasshopper population of 1939.

The fall (1939) survey indicated that more eggs were in the ground in the western third of the state than at any time since 1935. Egg deposition was heaviest in Lane, Hodgeman and Greeley Counties.

Green June Beetles (Cotinus nitida) were more numerous in eastern Kansas than in 1938. They were reported eating the leaves and fruit of peach and other fruits at Arkansas City and Topeka during July. Newspaper accounts reported them incorrectly as Japanese beetles which are now not known to occur in this state.

Harlequin cabbage bugs were more abundant than in 1938. Turnips and cabbage were reported injured at Hutchinson and in southeastern Kansas Counties. They were abnormally plentiful in Riley County during August but no damage was done.

Hessian fly had a relatively low population and did no damage except in extreme southeastern counties. The overwintering population was heavier than in 1938. Adults emerged in April and May and a somewhat larger spring brood than for about five years resulted. The numbers however were barely enough to cause commercial losses except in Cowley, Chautauqua, Dickinson, Montgomery and Marion Counties. R. H. Painter and E. T. Jones found relatively few stalks down however and large numbers of parasites. It was apparent that the fly was building up.

The extreme drouth of the summer and fall was exceedingly unfavorable to this insect. By winter, surveys indicated that the hessian fly had been virtually wiped out. The year closed with a smaller than usual population in hibernation. However, Dr. Painter found as high as 50 to 60 percent of plants infested in his wheat nursery after fall rains in October. They must have emerged after October 10 which is a week beyond the fly free date.

Leafhoppers (Erythroneura spp.) were exceptionally plentiful the latter part of April in Riley County in Spiraeas, Japonicas, rose bushes and redbuds. Injury to wall paper and pictures especially oil paintings supposedly caused by leaf hoppers was observed in a Manhattan home. Oily spots near dead leaf hoppers offered some verification.

MITES AND TICKS

Wheat mites were again numerous and destructive on wheat throughout western Kansas. Dr. R. H. Painter observed that they

occurred alone in some fields but in others, red spider mites were also present. They were present in numbers in Ellsworth, Gove, Trego, Thomas, Rawlins, Cheyenne, Dickinson, Meade, Clark, Ford, Edwards and Finney Counties. Messrs. R. H. Painter and H. H. Walkden observed on surveys the middle of May that wheat mites occurred largely south of highway 24 but north of it they were largely replaced by red spiders.

Brown spots presumably the result of attacks by these mites were common in wheat and barley fields in the western half of the state. Edges of fields were more severely damaged than the centers. Drouth delayed growth of wheat and accentuated injuries. Injured wheat fell over and cured. Such spots were frequent around Garden City according to Mr. Roy Fritz and resembled drouth injury. It is believed that the hot summer weather of 1938 and 1939 destroyed many mite eggs.

Chiggers were fully as plentiful and annoying in 1939 as in 1938 particularly during June and July. Many letters concerning these pests came in. Yard dusting with sulphur was common but rains in June washed it off. They were a constant subject of conversation and newspaper publicity.

Sheep scab mites occurred during January in Cowley, Elk, Greenwood and Chautauqua counties in greater numbers than usual. An infested flock was sold and scattered at a sales pavilion.

Red spider mites were again more plentiful and destructive than normal from May to September in various parts of the state. During May, injuries were caused to wheat, especially north of highway 24 and to ornamentals. Heavy infestations occurred in late summer on evergreens in Riley County and many other eastern counties. They were less abundant in Dickinson County.

Clover mites were abundant in the Kaw Valley in April and some clover patches were killed by them. This species was more plentiful than usual in alfalfa fields during June.

Dermacentor nigrolineatus the red-brown winter tick was taken early in the spring on cattle from the south. It was first taken in Kansas in 1936 but this state is too far north for the species to survive the winters.

Several species of ticks were taken in Kansas for the first time as far as known. **Rhipicephalus sanguineus**, the brown dog tick became exceedingly plentiful around the veterinary clinic building and a Manhattan home became so heavily infested in September that a general fumigation was necessary. It is believed that this tick was introduced with southern dogs sent to the veterinary hospital for treatment. The residence possibly became infested from this source.

Ornithodorus talaje Duges was taken in a hotel in a Kansas town. The ticks were reported crawling on the walls and dropping on beds.

They were identified by F. C. Bishop who stated they were usually associated with bats and rodents. Some live specimens were sent in in rubbing alcohol. Upon receipt, they were removed from the alcohol, washed in tap water and after a delay of some three days, three or four of the ticks attached themselves to a rabbit and fed.

. . . . . .

Mosquitoes were more numerous in 1939 than in 1938. They built up to abnormal numbers as a result of June rains and continued plentiful until October. Egg masses were readily found in water filled receptacles all summer in Riley County. There was a virtual outbreak of mosquitoes the latter part of June in the Neosho and Marais de Cygnes river valleys. Apple pickers in northeast Kansas were severely attacked in late summer.

Equine encephalomyelitis considered by many to be mosquito borne was less prevalent in the state than in 1939. There were 727 cases during the summer in the state of which 121 resulted fatally

Onion plant bugs were somewhat numerous during 1939 but there was little loss to onions in spite of rather severe top injury. They appeared in destructive numbers about May 20 in Riley County but left about June 1. Onions were favored by good growing conditions and soon overcame largely an injury that might have killed the onion in less favorable years. The bugs were last seen on the tops of wild onions.

A small **Pentatomid** bug of unknown species was reported attacking beets and melons in Meade County during early June. The same or a similar species attacked wheat in Jewell County. Several species of these bugs were unusually plentiful in alfalfa fields during September in Riley County.

A flight of pentatomids (**Thyanta custator**) occurred at Hutchinson September 15 from 11:30 to 2 o'clock and at Oakley on September 19.

Small pentatomids attacked wheat in June. They were common on wheat heads and there were some indications that they fed on the developing kernels.

The abnormal abundance of Pentatomids during 1939 has prompted some to call it a "Pentatomid year."

The rose budworm destroyed a high percentage of rose buds on untreated roses during May and June in Riley County. It was perhaps less p'entiful than in 1938.

Cedar Scale (Cryptaspidiotus shasta) was as abundant and destructive in Riley, Phillips, Norton, Clay, Dickinson, McPherson, and Finney Counties during June and July as in 1938. All the cedar trees on the campus were sprayed June 1 and 2 and on June 30 to July 3 to destroy the crawling young. The outbreak in 1938 and 1939 is

regarded as the worst in a generation. Many wild cedars were killed by the scale. Spraying with 1 pint of nicotine sulphate in 100 gallons of water plus 1 quart of summer spray oil (Verdol was used) gave excellent results. No sprayed trees were killed by the scale. There are four generations of the scale during the year. It has been highly parasitized but parasites did not control it.

The **pine leaf scale** was reported by R. H. Beamer as unusually scarce in 1939.

The **American saw fly (Cimbex americana)** was less numerous during June than in 1938 but was plentiful enough to do some defoliation in southeast Kansas. The population was well above normal. Some elms were defoliated at Coffeyville in June.

The **rose sawfly** was practically absent in the state in 1939. Its numbers and injury were well below 1938 and less than normal. Only a few rose bushes were observed during May and June to have been attacked.

Silver fish were the subject of somewhat more than usual number of inquiries from many counties. Observations indicated, however, that the numbers in Riley County were normal.

Sheep nose bots were present in annoying numbers in various western counties in April and May. Adults also caused annoyance by deposition of young during July.

The **southern corn leaf beetle (Myrochrous denticollis Lec.)** was reported many times as doing damage to corn in southeastern Kansas south of Garnett the latter half of May. Several hundred acres were reported damaged.

The **striped cucumber beetles** were definitely less numerous and destructive than last year. A good crop of cucumbers was harvested in July from the departmental plots as a result of frequent dustings with Pyrocide "10" and in spite of the drouth. The vines finally succumbed to the wilt disease however. This beetle was unusually abundant on late squash in October.

The **12-spotted cucumber** beetle was more abundant during September than for a number of years. They caused some damage to late squashes, flowers and buds of late fall roses, chrysanthemums and other fall flowers.

"Stored grain insect pests were more abundant in Kansas during 1939 than they have been at any time during the past 20 years" according to Dr. R. T. Cotton. "Of 1,147 cars of grain inspected on the Kansas City market in November, 33 percent graded weevily. A survey of farm stored grain in Saline County showed that at the end of November, 93 percent were infested. The insects more frequently found were, the flat grain beetle, the Cadelle, the sawtoothed grain beetle, the rice weevil and the granary weevil.

The Tenebrionids **Cynaeus angustus** Lec. and **Tenebrio picipes**

Hbst. were found infesting grain in Riley County. The former species has never before been recorded as a pest of stored grain. The latter species has been recorded occasionally in the United States and Japan as a pest of stored cereals, but, has not been previously infesting grain in Kansas."

The sugar cane root stalk weevil (Anacentrinus deplanatus Csy). was discovered by Prof. H. R. Bryson causing injury for the first time in Kansas to some kinds of sorghum during August in Riley County. This weevil was previously collected in the county on barnyard grass.

Squash bugs (Anasa tristis) were again so plentiful in Riley County and other truck growing areas as to be the limiting factor on the crop. Both squash and pumpkin vines were killed promptly during July and August but the bugs clustered on the fruits after the vines were killed. While they were the most serious pests of these crops in 1939 they were not quite so plentiful as in 1938.

Tarnished plant bugs passed the winter of 1938 in larger numbers than usual and were common in alfalfa fields and at lights in Riley County the latter part of March. The adults were in flight on warm days throughout March. The first generation was nearly grown the middle of May. It was thought the paucity of flowers on the first growth of alfalfa may have been connected with the large numbers of this species. Injury was reported from south east Kansas.

Tomato horn worms were slightly more numerous and destructive than in 1938 but their numbers were perhaps below normal. They were reported causing damage at Jewell, Hutchinson and Manhattan during August.

Termites continued to be a major subject of correspondence but it is un'ikely that they were more numerous or more destructive than in 1938. The earliest swarms emerged in Riley County March 12 and continued daily for a week. Rains in June caused increased activity giving the impression that they were more abundant than usual. Swarms were seen on September 30 and October 14. Damage to living trees and other vegetation continued to constitute an increasing proportion of the injuries and reports. This is a major problem in the state. They killed year old apricot trees in Barton County and Chinese elms at Downs in April.

Walnut worms were less numerous and destructive in the state than usual. The first generation of larvae defoliated some trees particularly in Southeast Kansas during July being most pronounced from Greenwood County east. The second generation in August did about the same amount of defoliation and the same general region. This insect was scarce in Riley County.

The beet webworm was plentiful in all western Kansas counties during August but foliage injury was largely confined to Russian

thistles but some young alfalfa was injured. They were particularly plentiful at Hays and Ellis.

The **garden webworm** had about the usual population. A few larvae were readily found during August and September. They were reported injuring alfalfa in Barton County in September and to developing seed crops at Halstead.

Wheat saw fly larvae were reported by Dr. R. H. Painter to have been abundant in wheat in Ellsworth and Cheyenne Counties during May. The numbers were below normal and below 1938.

The **wheat stem maggot** was at a low point in its cyclic population curve in Riley County according to Dr. R. H. Painter. They were abundant, however, in the experimental fields early in June in Cherokee and Neosho Counties. "White heads" were readily seen in fields throughout southeastern Kansas.

Wheel bugs (**Arilus cristatus** Linn.) and **Triatoma sanguisuga** were exceptionally plentiful during 1939 as judged by specimens of the former sent in by correspondents and by collected specimens of the latter in Riley County.

White grubs were less plentiful in 1939 than in 1938. No serious damage resulted anywhere in the state except that of the **wheat white grub** in south central Kansas. This outbreak was described in the 1938 summary and since that wheat was harvested in June 1939 the loss due to that outbreak was largely realized in 1939. This insect was especially abundant in Sedgwick, Harper, Reno, and Rice Counties.

Mr. Roy Fritz reported collecting adults of this species on Finney and Seward Counties which is believed to represent a south western extension of the range of this species. This species was again abundant during September in south central Kansas but because of the lateness of the wheat sowing, not much damage was done. The adults were unusually plentiful during July at the Manhattan Country Club. They are apparently increasing there. June rains largely overcame earlier injury to the grass there.

Common white grubs were observed by Professor Bryson to be most numerous in April and May in gardens, strawberry patches, and grassy plots. Adult Phyllophaga were late in emerging for flight in Riley County appearing, however, near the end of May

Slight injury to fall sown wheat and to blue grass lawns occurred in Riley County in September.

Wireworms (Aeolus dorsalis) were observed by Prof. H. R. Bryson to be numerous in some wheat fields of Geary County in March and April but no injury was done.

SUMMARY AND CONCLUSIONS

Kansas in 1939 had the third warmest and fifth driest year in the 53 years of statewide weather records. Prolonged drouth from the

latter part of August to the closing days of December was the most severe on record for the time of year. Practically every section of the state received less than normal precipitation for the year. The average by sections was 26.54 inches, eastern third; 20.91 inches, middle third; and 12.79, western third. This was the ninth year in the drouth cycle which began in 1930. For the whole state the average moisture fall was 20.08 inches, or 6.35 inches below normal and 7.21 inches less than the 1938 average. June had the heaviest rainfall for 50 years causing losses by floods to wheat at harvest time and loss by shattering because of delayed cutting. The temperature was cool and pleasant but humidity was higher than usual. More snow fell this year than in any since 1924. It was unusually heavy late in February and the last days of December. Average temperature for the year was 57.8 degrees, 2.9 above normal and only 0.7 degrees cooler than the warmest year of record, 1934.

The following insects were in **outbreak** in 1939; green bug, pea aphid, elm leaf aphid, blister beetles, canker worms, pale western cut worm, false wire worms, screwworm flies, grasshoppers (west only), brown mites, red spiders, chiggers, cedar scale, squash bugs and wheat white grubs (spring).

The following forms and most of these mentioned above were **more numerous** in 1939 than in 1938: corn seed beetle, ailanthus web worm, boxelder aphis, cabbage aphid, cotton wood petiole gall aphid, apple leaf skeletonizers, common stalk borer, boxelder bugs, cattle grubs, codling moths, Colorado potato beetles, chinch bugs (fall), wheat head army worms, fleas, green June beetles, harlequin bugs, chiggers, clover mites, common pentatomids, silver fish, tarnished plant bugs, tomato horn worms, wheel bugs and Triatomas and stored wheat pests.

The following insects were approximately **as plentiful** in 1939 as in 1938; yellow ants, alfalfa caterpillars, carrot beetles, clover leaf weevils, pale western cut worm, corn ear worm, variegated cut worm, black crickets, false wire worms, wheat white grub, biting flies, screwworm flies, leaf hoppers on grape, wood bine, spiraeas, and roses, brown mites, red spiders, rose slugs, cedar scale, southern corn root worm, termites, beet and garden web worms.

The following insects were **scarce or practically absent** in 1939· cutworms especially army and common garden species, hessian fly (in spring), rose sawfly, wheat stem maggot.

The following species in addition to those above were **less plentiful** in 1939 than in 1938: house ants, kafir ant, melon aphid, blister beetles, flat headed and other borers, grasshoppers, hessian fly (in fall), horse flies, onion plant bug, peacock butterfly, rose bud worm, American saw fly, striped cucumber beetle, squash bugs, walnut worms, wheat saw fly, white grubs and wireworms.

GRASSHOPPER POPULATIONS (ORTHOPTERA, ACRIDIDAE) OF TYPICAL PASTURES IN THE BLUESTEM REGION OF KANSAS*

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Studies of the prairie grasslands by Weaver (1931) and others indicate that the prairie is rapidly losing ground in its struggle against the encroachments of the plow. In certain of the prairie states, the remaining stands of native grasslands are largely confined to narrow railroad right-of-way, fence rows, and roadsides. However in the Flint Hills or Bluestem region, which extends north and south through the middle of the eastern fourth of Kansas, a large portion of the soil is still covered with its natural heritage of bluestem grasses. Much of this bluestem area has been pastured or mowed but in the main is in a fair state of preservation in spite of occasional or even frequent mistreatments by overgrazing. Being the last large remaining stand of prairie grasses it undoubtedly bears the most representative fauna of the original prairie that can be found under present conditions. Outstanding and conspicuous among the insect fauna of the prairie are the grasshopper of the orthopteran family Acrididae.

LITERATURE. In Kansas the only intensive survey of the grasshoppers inhabiting the native grasses was that made by Woodruff (1937) who collected in a native bluestem meadow, a corn field an alfalfa field, and a weed patch through July until August 21 of 1936. He noted that the native grasslands supported a quite different grasshopper fauna from the other habitats in that the genera **Orphulella, Mermiria,** and **Syrbula** were dominant in the prairie though scarce elsewhere. In the cultivated areas species of the genus **Melanoplus** were dominant.

After analyzing the collections taken during the annual grasshopper surveys of the state, Shotwell (1938a, 1939) recorded the species according to habitats, including those occurring in pastures. His pastures were, however, largely grazing lands in the western part of the state and were not representative of the bluestem pastures of the tall grass prairie.

Injury to the heads of native grasses was observed by Wilbur (1936) in 1932. Similar injury tho to a lesser degree has been noted each year since. The insect attack was such that the injured heads

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withered and failed to produce seeds.

A list of the Orthoptera collected from a large tract of native prairie near Lincoln, Nebraska, was published by Whelan (1938). This area is similar to the one on our college farm which is called the native grass pasture in this paper. Whelan listed 32 species of Acrididae, 11 of which were mentioned as being common.

Hendrickson (1930) collected all of the insects from a series of native prairie habitats in Iowa and obtained a large series of grasshoppers. An ecological survey of the Orthoptera of Oklahoma was summarized by Hebard (1938) who listed the collections from grasslands under pasture and range. Neither of these habitats corresponds to the bluestem prairies in Kansas. Isely (1937, 1938) studied the food habits of acridians of Northeastern Texas, many of which are an important part of the acridian fauna of Eastern Kansas Acridians of the grasslands were included in a series of habitat collections made by Horsfall, Dowell and Palm (1933) in Northwestern Arkansas. All of these papers emphasized the differences between the grasshopper populations of native grasses and of crops in both numbers and species.

GRASSLANDS UNDER OBSERVATION. Some years ago a study of the insect fauna of grasslands was begun at the Kansas Agricultural Experiment Station. The purpose of the study was to determine the insects present, their biology and behavior, and the fluctuations in their populations as affected by weather, grazing methods, and other factors. As a part of this study three grassland areas located in the Animal Husbandry pastures were selected for continuous and systematic sampling throughout the growing season for a period of years. The areas selected were tracts of 40 acres or more and consisted of native prairie grass, Kentucky bluegrass, and orchard-brome grass pastures. From a study of the insects of the native prairie area it was hoped to determine to some extent the instect fauna of the original prairie of this section. All relationships between the insects of the grasslands and the insects of the adjoining crops were noted. The following report largely concerns the grasshoppers secured during the collections for the seven years beginning 1933 and continuing through 1939.

The native prairie pasture was as good an example of Weaver's upland prairie as could be found in this region. The dominant grasses were little bluestem (**Andropogon scoparius**) and big bluestem (**A. furcatus**) with varying amounts of side oats grama (**Bouteloua curtipendula**), hairy grama (**B. hirsuta**), prairie dropseed (**Sporobalus asper** and **S. heterolepis**), prairie June grass (**Koeleria cristata**), and others. Apparently the only introduced grass was Kentucky bluegrass (**Poa pratensis**) which disappeared entirely during the drouth of 1934. Native herbs were scattered throughout the pasture.

The pasture was grazed intermittently each year and for a time showed the effects of the 1934 drouth but at present shows little evidence of natural or artificial mistreatment. This pasture has been burned off both by accident and by intent on different occasions during the years of observation.

The area considered as the Kentucky bluegrass pasture started out with a fine stand of this grass but the drouth of 1934 practically eliminated it. Only a small quantity remained after the fall of 1934, its place being taken by a succession of weeds and annual grasses. Mustards came in first and were prominent among the weeds but disappeared almost entirely following a severe aphid infestation. Annual grasses followed quickly, particularly little barley (**Hordeum pusillum**) and annual brome (**Bromus secalinus**). Then came a heavy growth of love grass (**Eragrostis spp.**) and at present prairie dropseed is becoming established in abundance. The Kentucky bluegrass has scarcely gained during the past five years.

The orchard-brome grass pasture consisted of those cultivated grasses recommended for seeding in this area. The original area observed was a stand which very successfully resisted both the drouth and the heavy grazing. However, it was turned under in 1938. Observations were continued on a newly planted field of orchard-brome grass across the road from the original plot.

METHODS. Each year the collections were started during April, the exact time depending on collecting conditions, and were continued throughout the growing season until severe frosts occurred. Semi-weekly collections were intended but occasionally rains interfered. Most collections were made between 11:00 A. M. and 2:00 P. M.

The collecting was done by means of a specially constructed, long-handled, square net, the mouth of which was one square foot in area. Twenty-five sweeps of this net in each plot, each sweep covering about three feet, constituted a collection.

Numerous criticisms have been leveled at the sweep method as a means of evaluating insect population. The writers certainly do not propose this as the best means of surveying grasshoppers, the methods devised by Shotwell (1935, 1938b) being much superior. The sweep method, however, does make it possible for a busy entomologist to keep in touch with many of the events and trends in the field that would otherwise escape him. It likewise appears entirely adequate for population studies when large numbers are treated and when conclusions are not drawn from minor differences.

A large series of the grasshoppers collected during the first two years were identified by Hebard, who published the records along with others from the Kansas State College collection (1934) as an addition to his Orthoptera of Kansas (1931). Later specimens were identified by members of our own laboratory. We have been unable to distin-

guish with certainty some of the species, particularly **Orphulella speciosa** and **O. pelidna**, and the females of **Melanoplus femur-rubrum, M. mexicanus** and **M. confusus**. The **Orphulella** species were grouped, and the females of **Melanoplus** were distributed in accordance with the prevailing number of males.

WEATHER. As it developed, the project was started at the beginning of the hottest and most severe period of drouth on record in Kansas. The following indicates the extent of this drouth as recorded at Manhattan:

1933—rainfall deficient 9.55 inches from a 53-year average; 27 days of 100° F. or more; severe June drouth.

1934—rainfall deficient 12.11 inches; 64 days of 100° F. or more and 23 days of 110° F. or more; 3½ months of most severe drouth beginning May 15.

1935—rainfall excessive 6.22 inches; 33 days of 100° F. or more, wet spring and wet fall but 48 days beginning July 1 until August 18 with only 0.2 inches of rainfall.

1936—rainfall deficient 8.42 inches; 60 days of 100° F. or more severe drouth during growing period. Beginning May 26 and ending August 19 only 1.47 inches of rainfall.

1937—rainfall deficient 11.15 inches; 38 days of 100° F. or more, only two rains of more than 0.71 inch occurred during the entire growing season and these were cloudbursts.

1938—rainfall deficient 4.09 inches; 20 days of 100° F. or more, severe drouth in September and October.

1939—rainfall deficient 4.23 inches; 18 days of 100° F. or more, severe fall drouth.

It can be seen that during the period of these collections, there has been a shortage of 43.33 inches of moisture which is approximately 20 percent below the amount expected from the 53 year average. Also 260 days or 10 percent of the total number of days have had temperatures of 100 ° F. or more.

POPULATIONS OF NYMPHS. During the seven years period 13,937 nymphs and 5,444 adults of grasshoppers were taken. The number of nymphs is believed to be fairly indicative of the 'hopper populations because they were easily captured by the sweep method. As the observations progressed the nymphs of several of the species could be distinguished, but as this was not done in the earlier collections, the nymphs are therefore treated as a group. The distribution of nymphs according to years and habitats is given in Table 1:

The meadow grasshopper completely disappeared following the 1934 season, but in 1939, a fairly large collection was taken from each of the three pastures.

TABLE 1

The distribution of grasshopper nymphs by years and by habitats.

Year	Native Prairie	Kentucky Bluegrass	Orchard Brome	Total
1933	2346	463	617	3426
1934	1175	491	589	2255
1935	287	183	117	587
1936	651	543	1309	2503
1937	459	910	1106	2475
1938	315	793	474	1582
1939	405	388	316	1109
Total	5,638	3,771	4,528	13,937

This is in striking contrast to the populations of the nymphs of the meadow grasshoppers of the family Tettigoniidae as indicated in Table 2.

TABLE 2

Distribution of nymphs of Tettigoniidae by years and by habitats.

Year	Native Prairie	Kentucky Bluegrass	Orchard Brome	Total
1933	71	190	363	624
1934	0	5	3	8
1935	0	0	0	0
1936	0	0	0	0
1937	1	0	0	1
1938	4	0	1	5
1939	27	16	85	128
Total	103	211	452	766

From Tables 1 and 2, it is evident that the year 1933, before the serious drouth set in, carried the largest nymphal populations of both acridians and meadow grasshoppers. Yet in this part of the state there was no problem of grasshopper injury to crops until 1935. The smallest collection of nymphs for the seven-year period was taken during 1935. This suggests that numbers of grasshoppers in the grasslands cannot be depended on as an index of possible injury to crops by grasshoppers. The reason for this will be apparent when the dominant species for the different years are discussed.

In Figure I is presented bar graphs of the nymphs collected for the entire seven years. Each bar represents the day's collection from the three grassland areas and thus consists of the acridians captured by 75 sweeps of the net. Only the general pattern of the charts should be considered and these simply to indicate trends. The uneven nature of some of the curves may be attributed to the weather, to a peculiar behavior on the part of the grasshoppers or to chance. No explanation is offered for such unusual collections as those especially large ones taken early in June of 1934 and in the middle of June of 1938.

The pattern of the 1933 collection is reasonably regular in outline and represents a nymphal population which starts in late April, progresses slowly through May and reaches a peak through June and early July, when it recedes quickly. A small nymphal population is maintained through August and well into September. A similar pattern is maintained during the years 1936, 1938, and 1939 with only minor differences.

In 1935, the year of least abundance of nymphs, no peak is evident. It was during this year that nearly 15 inches of rainfall occurred in May and June. At the time, it was thought that there would not be a grasshopper problem because of such an excess of moisture and because of subnormal temperatures. The lack of a heavier spring hatch is probably due to the large hatch which occurred during the late summer and fall of 1934, too late for the individuals to mature and deposit eggs.

The nymphal populations of 1934 and 1937 are quite out of line with those of the other years. Two distinct peaks of nymphal abundance occured during 1934. A population similar to that of 1933, except for reduced numbers, was present during May and June and practically terminated by the middle of July. On the second and third of September two rains totaling 1.33 inches occurred to break a terrible drouth of three and one-half months. During this drouth there were only two showers of more than half an inch of rainfall, and these were of less than 0.65 inch. Immediately following these early September rains, a second major hatch of grasshoppers occurred and nymphs were present throughout the mild fall until they were destroyed by freezes in November. The extent of this late hatch was 28.6 percent of the total season's collection (Table 3).

In 1937, collected material showed an irregular peak from late May until early July and included a considerable number of nymphs throughout August and into September.

TABLE 3

Percentage of acridian nymphs collected after July 31.

Year	Percentage of nymphs after July 31
1933	4.15
1934	28.60
1935	9.37
1936	4.95
1937	16.52
1938	5.82
1939	1.98

Two explanations are suggested for the unusual hatches of 1934. It has long been known that in certain years **Melanoplus mexicanus**

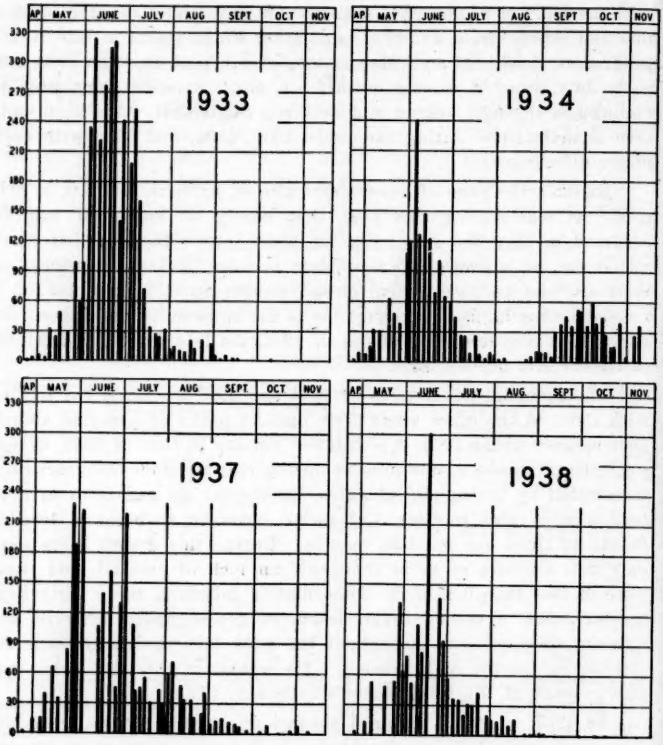

FIGURE I

has a second generation. Most of the nymphs recorded during the late summer and fall for each of the seven years were of this species. Certain of the Oedipodinae formed most of the exceptions and these exceptions were few in numbers. It is possible that the excessive drouth of the latter half of May, and of June, July, and August may have interrupted the normal spring hatch of M. **mexicanus** and that the remaining eggs awaited the rains of early September for further development. However, it seems more probable that the September hatch represented a partial second generation. A diapause broken by winter's cold characterized the development of the eggs of most grasshopper species. Normal winter hardening results when excessive water in the protoplasm is thrown off, creating a condition of physiological drouth. In the absence of experimental data, it seems

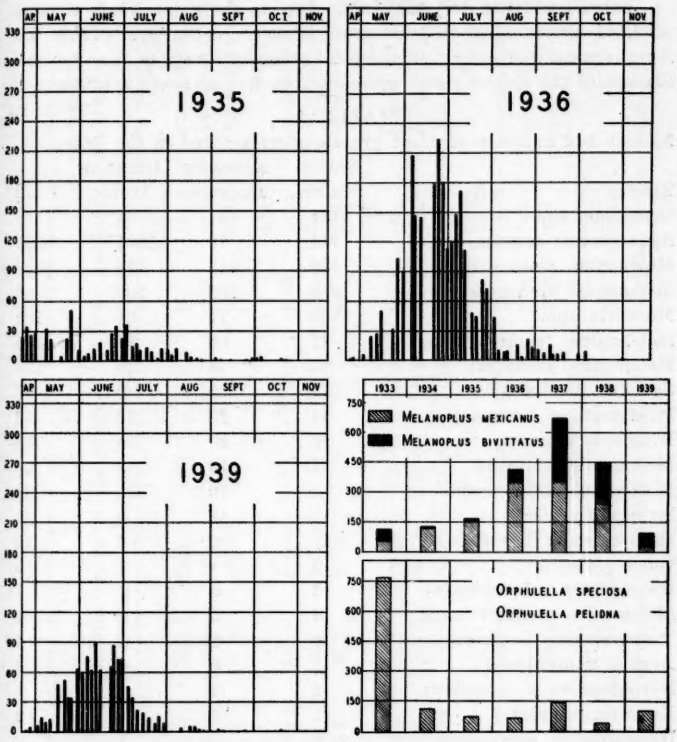

FIGURE I

Graphs showing numbers and seasonal distribution of acridian nymphs, 1933 to 1939 inclusive. At the lower right are graphs comparing collections of adults of **Melanoplus mexicanus** and **M. bivittatus** (above) with **Orphulella speciosa** and **O. pelidna** (below).

reasonable to postulate that excessively hot, dry summers might result in a physiological drouth, comparable to that which takes place during the winter. Many of the farmers of Kansas know that **M. mexicanus** oviposits in bare soil without the advantage of any cover. This bare soil frequently attains surface temperatures of 130° F. and may go up many additional degrees. Whatever the explanation, the hatch was dependent upon the September rains just as was the emergence of the Chloropidae from the same area (Wilbur and Sabrosky, 1936).

POPULATIONS OF ADULTS. During the seven years a total of 5,444 adults of 33 species were taken in collections (Table 4). Approximately 68 percent of the total collections were of four species. Sixteen of the species were represented by five or fewer specimens.

TABLE 4

Species and numbers of adult grasshoppers secured in the collection.

Species	Native prairie	Kentucky bluegrass	Orchard brome	Total
Orphulella spp.	1134	147	64	1345
Ageneotettix deorum	146	70	1091	1307
Melanoplus mexicanus	129	413	755	1297
Melanoplus bivittatus	58	153	530	741
Mermiria spp.	153	11	31	195
Melanoplus femur-rubrum	42	66	37	145
Melanoplus packardii	75	13	35	123
Syrbula admirabilis	14	39	2	55
Pardalophora haldemanii	11	22	13	46
Hippiscus rugosus	10	20	14	44
Melanoplus confusus	17	16	7	40
Melanoplus differentialis	4	10	25	39
Hypochlora alba	5	12	0	17
Hesperotettix v. viridis	13	2	0	15
Opeia obscura	3	1	1	5
Phoetaliotes nebrascensis	4	0	1	5
Melanoplus scudderi latus	4	0	0	4
Trachyrhachis k. kiowa	0	2	2	4
Arphia xanthoptera	3	0	0	3
Hesperotettix v. pratensis	2	1	0	3
Eritettix simplex	1	1	0	2
Hesperotettix speciosus	1	0	1	2
Chortophaga viridifasciata	0	2	0	2
Aulocara elliotti	0	0	2	2
Arphia simplex	1	0	0	1
Arphia pseudonietana	0	1	0	1
Phlibostroma quadrimaculatum	1	0	0	1
Dissosteira carolina	0	0	1	1
Boopedon maculatum	0	0	1	1
Encoptolophus sp.	0	0	1	1

HABITATS. The total number of species represented in the various grasslands was about equal, there being 26 species taken from the native grass pasture, 21 from the Kentucky bluegrass pasture, and 22 from the orchard-brome grass pasture. There was, however, a great diversity in the importance of the various species and groups of species in the different pastures as indicated in Table 5.

TABLE 5

Distribution by years of the important groups or species of grasshoppers according to habitat

	Total adults	Av. %	Percentage of total collections 1933	1934	1935	1936	1937	1938	1939	
Native prairie	233	12.2	1.32	7.55	29.45	27.98	21.18	31.40	5.23	
Ky. bluegrass	642	64.2	36.84	81.11	56.41	78.99	74.67	67.32	16.67	Crop infesting[1]
Orchard-brome	1347	51.6	33.54	32.54	60.00	49.09	38.82	88.48	85.42	Melanopli
Total	2222									
Native prairie	1287	70.2	95.11	55.35	38.36	40.93	47.06	36.05	79.74	
Ky. bluegrass	158	15.8	38.84	8.89	28.20	13.45	5.59	12.68	27.78	Orphulella spp[2]
Orchard-brome	95	3.6	6.96	14.29	8.65	3.13	2.31	0.28	5.21	Mermiria spp.
Total	1540									
Native prairie	146	8.0	1.32	30.82	6.85	4.66	18.83	4.65	0.00	
Ky. bluegrass	70	7.0	14.29	2.22	3.85	1.68	9.21	5.85	5.56	Ageneotettix
Orchard-brome	1091	41.4	46.84	48.41	22.70	45.96	57.95	0.84	2.08	deorum
Total	1307									
Native prairie	168	9.6	2.25	6.28	25.43	26.43	12.93	27.90	15.03	
Ky. bluegrass	130	13.0	12.03	7.78	11.54	5.88	10.53	14.15	49.99	All others
Orchard-brome	77	3.4	12.66	4.76	8.65	1.82	0.92	10.40	7.29	
Total	375									

[1]Melanoplus mexicanus, M. bivittatus, M. femur-rubrum and M. differentialis.

[2]Orphulella speciosa and O. pelidna; Mermiria maculipennis macclungi, M. neomexicana, and Mermiria bivittata.

(Note—The 4 percentages in each column recorded for native prairie total 100 percent; the same is true for Kentucky bluegrass and orchard-brome).

Taking the collections for the entire period, the three most important species for the habitats observed were as follows:

Native prairie	Kentucky bluegrass	Orchard-brome
1. Orphulella spp.	1. M. mexicanus	1. A. deorum
2. Mermiria spp.	2. M. bivittatus	2. M. mexicanus
3. A. deorum	3. Orphulella spp.	3. M. bivittatus

For the individual years the importance of the species in the different habitats varied somewhat:

	Native prairie	Kentucky bluegrass	Orchard-brome
1933	1. Orphulella spp.	1. Orphulella spp.	1. A. deorum
	2. ----------	2. M. mexicanus	2. M. bivittatus
1934	1. Orphulella spp.	1. M. mexicanus	1. A. deorum
	2. A. deorum	2. Orphulella spp.	2. M. mexicanus
1935	1. Orphulella spp	1. M. mexicanus	1. M. mexicanus
	2. M. mexicanus	2. Orphulella spp.	2. A. deorum
1936	1. Orphulella spp.	1. M. mexicanus	1. A. deorum
	2. Mermiria spp.	2. M. bivittatus	2. M. mexicanus
1937	1. Orphulella spp.	1. M. mexicanus	1. A. deorum
	2. Mermiria spp.	2. M. bivittatus	2. M. bivittatus
1938	1. Orphulella spp.	1. M. mexicanus	1. M. mexicanus
	2. Mermiria spp.	2. M. bivittatus	2. M. bivittatus
1939	1. Orphulella spp.	1. S. admirabilis	1. M. bivittatus
	2. Mermiria spp	2. Orphulella spp.	2. M. mexicanus

During the more severe of the drouth years the crop infesting Melanopli assumed the dominance in numbers. The rise of **Melanoplus mexicanus** and **M. bivittatus** and the decline of **Orphulella** spp. is indicated in the graphs in the lower righthand corner of Figure I. In the native prairie the Melanopli rose from 1 percent to a high of 31 percent of the population and then dropped back to 5 percent. A similar situation occurred in Kentucky bluegrass with the Melanopli starting at 36 percent of the hopper population of 1933, then jumping to 81 percent and retaining a high level until 1939 when it dropped to 16 percent. The high percentage of Melanopli in the orchard-brome pasture in 1938 and 1939 is undoubtedly due to the substitution of a young stand of grass for the established stand previously collected. The same explanation explains the extreme drop in populations of **A. deorum** for the same years. **Orphulella** maintained its dominance in the native prairie during each of the seven years. Its numbers however were greatly reduced after 1933.

INDIVIDUAL SPECIES

ORPHULELLA spp. This refers chiefly to **O. speciosa,** altho it is probable that a few species of **O. pelidna** may likewise have been present. Adults of **Orphulella** were first taken in late June or early July and disappeared almost uniformly after the first week in September. The peak of abundance normally occurred from July 15 until August 15, altho in 1934, the peak was two to three weeks early. Of the 1,345 specimens taken during the seven years, 57 percent were males and 43 percent females. **Orphulella speciosa** more definitely characterized the bluestem grasslands in this region than any other grasshopper with the possible exception of **Memiria maculipennis macclungi.** Eighty-four percent of the total specimens were from the native prairie while only 11 percent were from Kentucky bluegrass and 5 percent from orchard-brome grasses. This percentage varied from year to year however. In 1938, the year of fewest specimens, only 41 percent were from the native grasses while during 1933, the year of greatest abundance, over 92 percent were swept from native grasslands.

AGENEOTETTIX DEORUM. This species was taken in greater numbers in the collections than any other species except **Orphulella speciosa.** It was predominantly found on the cultivated pasture of orchard-brome grasses. Of a total of 1,307 specimens, 84 percent were from orchard-brome, 11 percent from native prairie and 5 percent from Kentucky bluegrass. The species built up from a low ebb in 1933 to a high peak in 1937. At this time the orchard-brome pasture under observation was plowed and the observations were transferred to a new orchard-brome planting across the road. During the collections of 1938 and 1939 a maximum of 3 specimens per collection was taken from the young orchard-brome pasture. Aproximately 53 percent of all the specimens were males and 47 percent were females.

The earliest adults appeared in the collection between June 19 and July 12 and disappeared about the last week in September or the first in October. The peak of abundance occurred through July into August. In 1937 the peak was maintained until September 9.

MELANOPLUS MEXICANUS. This grasshopper had the dubious honor of being the most injurious crop infesting species in this region during the recent outbreak. Normally **mexicanus** is not abundant in good grasslands in the bluestem prairie area. However, during the drouth years it was able to build up large populations in both the Kentucky bluegrass and the orchard-brome grass pastures, more particularly the latter. Less than 10 percent of a total collection of 1,297 specimens was taken from native prairie grasses.

This species was one of the earliest grasshoppers to appear in the spring in the adult stage and it held on until the heavy frosts

came in the fall. The peak of abundance extended from the middle of June until late July. In 1934 there was a noticeable fall peak of adults between October 6 and November 9. Of all the specimens taken, 54 percent were males and 46 percent females.

MELANOPLUS BIVITTATUS. This species was the second most abundant **Melanoplus** found in the pastures. During the 7 years, there was a total collection of 741 adults of **M. bivittatus**, 71 percent of which came from the orchard-brome pasture, 21 percent from the Kentucky bluegrass and 8 percent from native prairie. The years of peak of infestation were 1937 and 1938 while during 1934 and 1935 the species was almost non-existent in our grasslands. The specimens taken were 51 percent males and 49 percent females. Adults of **M. bivittatus** usually appeared by the middle of June shortly after those of **M. mexicanus**. They did not last until frosts as **M. mexicanus** did but disappeared during September or early October.

MERMIRIA spp. These consist chiefly of **M. maculipennis macclungi** with a lesser number of **M. neomexicana** and a few of **M. bivittata**. Like Orphulella, Mermiria spp. are typical of the bluestem prairie. Of a total of 194 specimens 78 percent were from the native prairie, 6 percent from Kentucky bluegrass and 16 percent from orchard-brome grass. During the 1939 season this species was so abundant in various native grass pastures in this region that it reached outbreak proportions. Approximately 60 percent of the specimens collected were males and 40 percent were females. For the most part the adults appeared during the first half of July and disappeared during September and early October.

MELANOPLUS FEMUR-RUBRUM. This species was more evenly distributed over the three pastures than were any of the other species. Of the 145 specimens collected, 28 percent were from native prairie, 46 percent from Kentucky bluegrass and 26 percent from orchard-brome. Most of the specimens were taken during 1935, 1936, 1937 and 1938. While our records show that 49 percent of the adults were males and 51 percent females, any identification of females of **M. mexicanus, M. femur-rubrum** and **M. confusus** may be erroneous. The adults made their first appearance about the middle of June, with occasional specimens in late May. By October most of them were gone.

MELANOPLUS PACKARDII. This species is frequently found attacking crops during outbreak years but it is primarily an inhabitant of the native grasslands, particularly dry upland prairies. Of the 125 specimens taken, 60 percent were from the native prairie, 10 percent from Kentucky bluegrass and 30 percent from orchard-brome. The largest collections were made in 1935 through 1938. This species almost disappeared during 1939. The first adults usually appeared during late June or early July, but in 1936 one was taken on May 26.

The last specimens were collected during late August or September

SYRBULA ADMIRABILIS. This beautiful grasshopper species is frequently found in large numbers during late summer and early fall in the grasslands of this region. During the 1939 season it was present along with **Mermiria** in outbreak numbers in certain native grass pastures.

MELANOPLUS DIFFERENTIALIS. This species was one of the most injurious grasshoppers to crops in this region during the 1935, 1936, and 1937 seasons. The small numbers taken from the three pasture areas, however, indicate that it is not primarily an inhabitant of grasslands. During the 7 years of observations only 39 specimens were taken and these were mostly from the orchard-brome pasture. This grasshopper was actually present in the grasslands in greater abundance than the numbers indicate. Because of its alertness, it more easily evaded the net than most other species.

SUMMARY

1. A survey of the literature on Orthoptera reveals that several studies have been made of the grasshoppers inhabiting the grasslands of the Central and Southern Prairie states. The general results of these studies indicate that the grasshopper populations of the native prairie are characterized by the genera **Orphulella** and **Mermiria** while the genus most typical of the croplands and the weed patches is **Melanoplus.**

2. Collections were made thruout the growing season of the years 1933 thru 1939 on three representative pasture types; native prairie, Kentucky bluegrass, and orchard-brome pasture at the Kansas Agricultural Experiment Station.

3. The weather at Manhattan (1933-1939) constituted the hottest and most severe period of drouth on record for Kansas. There was a rainfall deficiency of 43.33 inches below that expected on the basis of a 53-year average. The temperature on 260 days of the collecting period reached 100° F. or more.

4. Nearly 14,000 grasshopper nymphs were secured in the collections, the largest number being taken in 1933 and the fewest in 1935. The grasshopper population of the native prairie was much greater than that in the Kentucky bluegrass and in the orchard-brome grass pastures in 1933 and 1934, but during 1936 thru 1938 the situation was reversed. The meadow grasshoppers were practically eliminated from the collections after 1933 until 1939. Large partial second generations of **Melanoplus mexicanus** occurred in 1934 and 1937.

5. Thirty-three species of adult grasshoppers totaling 5,444 specimens were taken during the collections. Approximately 68 percent of the adults collected were of four species while 16 of the species were represented by five or fewer specimens.

6. The studies confirmed the observations of others that the genera **Orphulella** and **Mermiria** dominate the grasshoppers in the native prairie. They also indicate that the crop-infesting species of the genus **Melanoplus** together with **Ageneotettis deorum** dominate Kentucky bluegrass and orchard-brome grass pastures.

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